Claims

What is claimed is:

1. An ion source for use in a mass spectrometer, comprising:

   an electron emitter assembly configured to emit electron beams, wherein the electron emitter assembly comprises carbon nanotube bundles fixed to a substrate for emitting the electron beams, a first control grid configured to control emission of the electron beams, and a second control grid configured to control energies of the electron beams;

   an ionization chamber having an electron-beam inlet to allow the electron beams to enter the ionization chamber, a sample inlet for sample introduction, and an ion-beam outlet to provide an exit for ionized sample molecules;

   an electron lens disposed between the electron emitter assembly and the ionization chamber to focus the electron beams; and

   at least one electrode disposed proximate the ion-beam outlet to focus the ionized sample molecules exiting the ionization chamber.

2. The ion source of claim 1, wherein the carbon nanotube bundles comprise one selected from single-walled carbon nanotubes, multi-walled carbon nanotubes, and a combination thereof.

3. The ion source of claim 1, further comprising an ion repeller disposed inside the ionization chamber to help the ionized sample molecules exit the ionization chamber.

4. The ion source of claim 1, further comprising a trap electrode to capture a portion of the electron beams exiting the ionization chamber to provide a feedback control of electron beam emission.

5. The ion source of claim 1, wherein the at least one electrode comprises at least one selected from a focusing half plate, a source slit plate, an alpha plate, an extracting lens, and a collimating lens.

6. The ion source of claim 1, wherein the second control grid are adapted to connect to an electrical source such that the energies of the electron beams are about 70 electron volts.

7. An ion source for use in a mass spectrometer, comprising:

   an ionization chamber comprising carbon nanotube bundles for emitting electron beams, wherein the carbon nanotube bundles are fixed on a conductive surface on a first wall of the ionization chamber;

   a sample inlet disposed on the ionization chamber for sample introduction;

   an ion-beam outlet disposed on the ionization chamber to provide an exit for ionized sample molecules; and

   at least one electrode disposed proximate the ion-beam outlet to focus the ionized sample molecules exiting the ionization chamber,

   wherein the conductive surface on the first wall and an electron-energy plate on a second wall of the ionization chamber are adapted to connect to an electrical source such that an electrical field is established to induce electron beam emission from the carbon nanotube bundles.

8. The ion source of claim 7, wherein the carbon nanotube bundles comprise one selected from single-walled carbon nanotubes, multi-walled carbon nanotubes, and a combination thereof.

9. The ion source of claim 7, further comprising an ion repeller disposed inside the ionization chamber to help the ionized sample molecules exit the ionization chamber.

10. The ion source of claim 7, wherein the at least one electrode comprises at least one selected from a focusing half plate, a source slit plate, an alpha plate, an extracting lens, and a collimating lens.

11. A mass spectrometer, comprising:

    a carbon nanotube-based ion source;

    a mass filter operatively coupled to the carbon nanotube-based ion source for separating ionized sample molecules based on their mass-to-charge ratios; and

    an ion detector operatively coupled to the mass filter for detecting the ionized sample molecules.

12. The mass spectrometer of claim 11, wherein the carbon nanotube-based ion source comprises:

    an electron emitter assembly configured to emit electron beams, wherein the electron emitter assembly comprises carbon nanotube bundles fixed to a substrate for emitting the electron beams, a first control grid configured to control emission of the electron beams, and a second control grid configured to control energies of the electron beams;

    an ionization chamber having an electron-beam inlet to allow the electron beams to enter the ionization chamber, a sample inlet for sample introduction, and an ion-beam outlet to provide an exit for ionized sample molecules;

    an electron lens disposed between the electron emitter assembly and the ionization chamber to focus the electron beams; and

    at least one electrode disposed proximate the ion-beam outlet to focus the ionized sample molecules exiting the ionization chamber.

13. The mass spectrometer of claim 12, wherein the carbon nanotube bundles comprise one selected from single-walled carbon nanotubes, multi-walled carbon nanotubes, and a combination thereof.

14. The mass spectrometer of claim 12, wherein the carbon nanotube-based ion source further comprising an ion repeller disposed inside the ionization chamber to help the ionized sample molecules exit the ionization chamber.

15. The mass spectrometer of claim 12, wherein the carbon nanotube-based ion source further comprising a trap electrode to capture a portion of the electron beams exiting the ionization chamber and to provide a feedback control of electron beam emission.

16. The mass spectrometer of claim 12, wherein the at least one electrode comprises at least one selected from a focusing half plate, a source slit plate, an alpha plate, an extracting lens, and a collimating lens.

17. The mass spectrometer of claim 12, wherein the second control grid are adapted to connect to an electrical source such that the energies of the electron beams are about 70 electron volts.

18. The mass spectrometer of claim 11, wherein the carbon nanotube-based ion source comprises:

    an ionization chamber comprising carbon nanotube bundles for emitting electron beams, wherein the carbon nanotube bundles are fixed on a conductive surface on a first wall of the ionization chamber;

    a sample inlet disposed on the ionization chamber for sample introduction;

    an ion-beam outlet disposed on the ionization chamber to provide an exit for ionized sample molecules; and

    at least one electrode disposed proximate the ion-beam outlet to focus the ionized sample molecules exiting the ionization chamber,

    wherein the conductive surface on the first wall and an electron-energy plate on a second wall of the ionization chamber are adapted to connect to an electrical source such that an electrical field is established to induce electron beam emission from the carbon nanotube bundles.

19. The mass spectrometer of claim 18, wherein the carbon nanotube bundles comprise one selected from single-walled carbon nanotubes, multi-walled carbon nanotubes, and a combination thereof.

20. The mass spectrometer of claim 18, further comprising an ion repeller disposed inside the ionization chamber to help the ionized sample molecules exit the ionization chamber.

21. The mass spectrometer of claim 18, wherein the at least one electrode comprises at least one selected from a focusing half plate, a source slit plate, an alpha plate, an extracting lens, and a collimating lens.

22. The mass spectrometer of claim 11, wherein the mass filter is based on a mechanism selected from magnetic sector, electrostatic sector, quadrupole, ion trap, and time-of-flight.

23. The mass spectrometer of claim 11, further comprising an electronic module operatively coupled to the carbon nanotube-based ion source for controlling electron beam emission.

24. The mass spectrometer of claim 11, further comprising a computer operatively coupled to the mass spectrometer.

25. The mass spectrometer of claim 24, wherein the computer comprises a program for monitoring a performance of the ion source.